Volume 10 DECEMBER 7, 1935 Number 6

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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAM

FOR THE

BERKELEY MEETING

AT

THE UNIVERSITY OF CALIFORNIA

DECEMBER 20–21, 1935

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

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AMERICAN PHYSICAL SOCIETY

Published seven times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published seven times a year during the months of February, April, June (2 issues), November (2 issues), and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary W. L. Severinghaus, Columbia University, New York, N. Y.

Entered at the post office at Lancaster, Pa., as second class matter.

Acceptance for mailing at a special rate of postage provided for in the Act of October 3, 1917, embodied in paragraph 4, Section 412, P. L. & R., authorized April 28, 1928.

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BERKELEY MEETING

THE 202nd regular meeting of the American Physical Society will be held in 212 Le Conte Hall at the University of California, Berkeley, California, on Friday, December 20 and Saturday, December 21, 1935. The morning session of the Physical Society will begin at 9 o'clock on Friday and the afternoon session at 1:30 o'clock on the same day. The session Saturday morning will begin at 9 o'clock and will be resumed at 2 o'clock if the number of papers on the supplementary program warrants it. Saturday afternoon, unless spent in session, will be open for tours of inspection of the Le Conte Hall and Radiation laboratories at the University of California.

Luncheon. Luncheons will be served at the Faculty Club on the Campus, following the morning sessions on Friday and Saturday. There will be a Society dinner Friday evening at the Faculty Club at the probable cost of seventy-five cents per plate.

Hotel Accommodations. The following Berkeley hotels are available in the immediate vicinity of the campus.

Hotel Durant: Detached bath, single occupancy from $2.00, double $2.50; with bath, single occupancy from $2.50, double $3.00. Three blocks from Le Conte Hall.

Hotel Whitecotton: Detached bath, single occupancy from $2.00, double $3.00; with bath, single occupancy from $2.50, double $3.00.

Hotel Claremont (one mile from the campus): Detached bath, single occupancy from $2.00, double $3.00; with bath, single occupancy $2.50, double $4.00; suites for from 3 to 5 persons, per person, $2.00.

Additional information will be available in the office of the Physics Department, 201 Le Conte Hall, on request.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.) Papers received after the program has been printed will be placed in the supplementary program.

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Editorial

Secretary, The American Institute of Physics Incorporated, 11 East 38th Street, New York, N. Y.

Other meetings for the current season are as follows:

203. December 31, 1935–January 2, 1936. Annual Meeting. St. Louis, Missouri.
204. February, 1936. New York City.
205. April, 1936. Washington, D. C.

LEONARD B. LOEB
Local Secretary for the Pacific Coast
University of California
Berkeley, Calif.

December 7, 1935.

PROGRAM

FRIDAY MORNING AT 9:00 A.M.

1. Gamma-Rays Emitted by Several Artificially Produced Radioactive Elements. J. R. RICHARDSON, *University of California.*—The energies of the gamma-rays from several artificially produced radioactive elements have been determined by studying the momentum distribution of the recoil electrons produced from a thin lamina of glass or mica placed in a cloud chamber. Only tracks starting in the lamina and projected within 12° of the forward direction were measured. The cloud chamber was filled with hydrogen (which greatly reduces the scattering of the particles) slightly above atmospheric pressure and was situated in a magnetic field of about 500 gauss. When the lamina had a surface density of about 100 mg/cm² the groups of recoil electrons ascribed to single gamma-ray lines of energy 3 MV or less were found to have a width of about 1200 $H\rho$ at half-maximum value. Measurements have been taken on the following radioactive elements produced from their stable isotopes by deuteron bombardment in the magnetic resonance accelerator of Lawrence:

Element	*Energy of gamma-rays in MV*
Na^{24}	1.2, 2.3, 3.4
Cl	2.5 (weak), 2.0 (strong)
A^{41}	1.5

More exact values of the energies and relative intensities will be given at the meeting.

2. Further Data on the Energies of Beta-Rays Emitted from Artificially Produced Radioactive Bodies. F. N. D. KURIE, J. R. RICHARDSON AND H. C. PAXTON, *University of California.*—The upper energy limits of the β-spectra of N^{13}, Na^{24}, Si^{31}, P^{32}, Cl^{38}, K^{42} were reported by the present authors at the Washington meeting, April 1935. We have repeated all these data with the cloud chamber containing hydrogen instead of oxygen in order further to reduce the scattering of the tracks. The following new elements have also been measured: F^{17}, A^{41}. The radio-argon was made by Dr. A. H. Snell. With these new data on eight elements we have examined the agreement between them and the shape of the distribution curves suggested by the Fermi theory and also by the Konopinski-Uhlenbeck variation of the Fermi theory. We find that the Fermi theory does not fit the data at all and that the K–U theory fits very well but leads to a very high upper limit, due to its demanding a high order of contact with the energy axis. The table gives the values of the upper limit as deduced from the data by fitting a K–U curve to them and also that got from simple inspection.

	Upper Limit			Upper Limit	
Substance	*Inspection*	*K–U curves*	*Substance*	*Inspection*	*K–U curves*
$N^{13}+$	1.65 MV	1.9	P^{32}	1.8 MV	2.1
$F^{17}+$	2.2	2.5	Cl	5	1.6, 6.4
Na^{24}	1.95	2.1	A^{41}	2.8	1.8, 3.6
Si^{31}	1.95	2.1	K^{42}	3.7	1.5, 4.6

The K–U plots suggest that Cl, A and K are each emitting two groups of β-particles. These are apparently not associated with the γ-rays observed in these elements.

3. Mass of the Neutrino from the Disintegrations of Carbon by Deuterons. T. W. BONNER, L. A. DELSASSO, W. A. FOWLER AND C. C. LAURITSEN, *California Institute of Technology.*—The reactions

$$C_6^{12}+H_1^2 \rightarrow C_6^{13}+H_1^1+Q_1$$
$$C_6^{12}+H_1^2 \rightarrow N_7^{13}+n_0^1+Q_2$$
$$N_7^{13} \rightarrow C_6^{13}+e^+ +\mu+Q_3$$

are typical of a class of reactions in which disintegration proceeds along two lines, one leading to a heavy particle and a proton, the other to the same heavy particle and a neutron, a positron, and a neutrino. Assuming no γ-rays to be emitted in either of the carbon disintegrations and assuming the masses of the proton, neutron, and positron to be known we may determine the mass of the neutrino provided the disintegration energies of the above reactions are found. Since the mass of the neutrino is thought to be small, if not zero, it is necessary to determine all of the energies involved rather accurately and we have thought it desirable to measure them under the same conditions. Our results are:

$$Q_1 = 2.65 \pm 0.07; \quad Q_2 = -0.37 \pm 0.03; \quad Q_3 = 1.45 \pm 0.10.$$

By using Feather's mass of the neutron (1.00859 ± 0.00011) the mass of the neutrino is calculated to be on the Bethe scale: $\mu = 0.00006 \pm 0.00017$.

4. High Altitude Measurements on the Energies of Cosmic-Ray Tracks. CARL D. ANDERSON, R. A. MILLIKAN AND SETH H. NEDDERMEYER, *California Institute of Technology.*—Ten thousand counter-actuated cosmic-ray photographs have been taken on Pike's Peak with the energy

measuring apparatus previously used at sea level. The great majority of the tracks are similar in kind to those obtained at sea level. All but about 100 are lightly ionizing tracks such as we have ascribed to positive and negative electrons. Showers are more frequent and on the average larger than those found at sea level. The few heavily ionizing positive tracks are in general interpretable as protons produced by nuclear disintegration. We wish to acknowledge the aid given to these researches by the Carnegie Institution of Washington and the Union Oil Company of California.

5. Design of Six Million Volt Magnetic Resonance Accelerator Unit for the Berkeley Magnet. DONALD COOKSEY, F. N. D. KURIE AND ERNEST O. LAWRENCE, *University of California.*—The need in various branches of science for intense neutron sources over long periods of time and for large quantities of radioactive substances has made it desirable to develop the technical aspects of the magnetic resonance accelerator to deliver high intensity deuteron beams under the exacting conditions of continuous operation. With this in mind a new accelerating unit has been designed to produce a deuteron beam of slightly over 6 MV. The gain over the 5.2 MV attained with the accelerator in present use in our laboratory is accomplished by a ten percent increase of the radius of the final circular path available to the ion beam in its interaction with the accelerating field. It is expected that changes in the ion source filament arrangement, better water-cooling of the various parts of the system and an increase in the effective beam area will result in a marked increase in the present deuteron current of 20 microamperes. Several changes in mechanical and electrical design, suggested by the past two years experience with the present apparatus, have been incorporated with the expectation of gaining thoroughly reliable operation. It is hoped to test the performance of this new unit before the meetings. Its various features will be shown by slides and discussed in some detail.

6. Interrelations of e, h/e and e/m. R. T. BIRGE, *University of California.*—With the now safe assumption that the grating wave-lengths of x-rays are correct, four points on the e_m diagram[1] are shifted to new values of m. With the additional safe assumption that e/m is approximately 1.7575×10^{7}, two of the four points are again shifted. The final results are—(1) six methods for determining h/e, with all six results consistent ($r_e/r_i=0.68$) and with a weighted average $(1.37588\pm0.00027)\times10^{-17}$, (2) four methods for e/m, all consistent ($r_e/r_i=0.44$) with a weighted average $(1.75762\pm0.00026)\times10^{7}$, (3) two methods for e, of which only one appears really precise (from λ of x-rays) with the result $(4.8029\pm0.0005)\times10^{-10}$. These three observed results are *not* consistent, *if* Bohr's formula for the Rydberg constant is true. Thus each of the three quantities, as calculated from the other two, deviates from the observed result by over ten times the *sum* of the probable errors of the observed and calculated values. One of the three following assumptions seems necessary: (1) The Bohr formula is incorrect, (2) calcite is not a geometrically perfect crystal, (3) the measured e/m is only 136/137 of its true value (Bond and Eddington theory).

[1] Science **79**, 438 (1934).

7. Ionization by Neutral Atom Beams. ROBERT N. VARNEY, *University of California.*—The balanced space charge method, used in previous experiments[1] to study ionization by positive ion impact, was adapted to the study of ionization of a gas by its own neutral atoms. A neutral atom beam was produced by forming a positive gas ion beam and allowing the beam to become neutralized by passing through its own gas. This charge exchange process has been investigated in the past, and is known to be highly efficient. The accelerated neutrals then entered the space-charge cylinder where any ionization they produced in the gas could be observed. The minimum energy at which ionization began was determined by varying the initial energy of the positive ions which made the beam. Ionization was observed to begin at the following energies of neutrals:

Ne in Ne	74 volts	Kr in Kr	40 volts
A in A	48	Xe in Xe	35

No ionization was observed in helium or in nitrogen. These are the lowest energies yet observed for ionization by heavy bodies. At most, only half of this energy is available for ionization because momentum must be conserved. The available energy is thus:

Ne in Ne	37 volts	Kr in Kr	20 volts
A in A	24	Xe in Xe	17.5

These are very near to the true ionization potentials of the gases.

[1] R. N. Varney, Phys. Rev. **47**, 483 (1935).

8. Negative Terms and Broad Lines in the Neutral Calcium Spectrum. H. E. WHITE, *University of California.*—Among the known energy levels of neutral calcium, strontium, and barium there are a relatively small number of known levels which lie above the common series limit of the regular sharp, principal, diffuse, and fundamental series. Some of these *negative terms* combine with lower terms to give sharp spectrum lines, and others combine to give broad nebulous lines. In strontium, for example, the $4d\ 6p$, $^3F^\circ$ term, in a continuum of $5s\ mf$, $^3F^\circ$, is observed to combine with the lower $5s\ 4d$, ^3D to give rise to five nebulous lines. It has already been proposed that the diffuseness of the lines is due to auto-ionization. It is reasonable to suppose that these same transitions should be observed as broad lines in calcium. A careful search for such lines in the exact spectral region where they are predicted has failed to show any trace of them. This is interpreted to mean that the levels are so broad that they spread out over the $4s\ mf$, $^3F^\circ$ continuum. If an atom is excited toward one of the $3d\ np$, $^3F^\circ$ states, where $n=5, 6, 7, \ldots$, it automatically goes over into the continuum and auto-ionizes. Combination lines for other predicted negative levels besides those identified by Russell have been looked for in calcium, but none have been identified.

9. Transmutation of Platinum by Deuterons: A Resonance Phenomenon. J. M. CORK AND E. O. LAWRENCE, *University of California.*—We have observed that platinum is rendered radioactive by bombardment with deuterons of energies above 3 MV. There are at least two distinct in-

duced activities having half-lives of about 40 min. and 10 hrs. Wilson cloud chamber observations show that the disintegration electrons are negative in sign and chemical tests show that the active substances are noble metals, most probably platinum. As deuterons of such low energy would not be expected theoretically to react to such an extent with the highly charged platinum nucleus, the transmutation function for the induced radioactivity was determined. A stack of thin (5-mm stopping power) platinum foils was bombarded with several microamperes of 5 MV deuterons for a few hours and the activities induced in the individual foils were compared. These measurements showed that the transmutation function does not rise monotonically with deuteron energy but exhibits sharp maxima and minima characteristic of resonance effects. For the short period activity the maxima occur at 3.9, 4.15 and 4.5 MV while for the long period activity the maxima are at approximately 3.45, 4.15 and 4.5 MV. These observations are interpreted as indicating resonance penetration of the platinum nucleus by deuterons.

10. Absolute Values of the Electron Mobility in Hydrogen. NORRIS E. BRADBURY AND RUSSELL A. NIELSEN, *Stanford University.*—A new method is described for the measurement of electron mobilities in gases. An electrical shutter method is employed in which the shutters take the form of two fine wire grids, alternate wires of which are connected to a high frequency alternating potential. Electrons pass through the grids only when the potential between adjacent grid wires is zero, and only electrons which cross the gas space in one-half cycle are received at the collecting electrode. A sharp maximum is thus observed in the electrometer current when the drift velocity of the electron multiplied by the time of one-half cycle is equal to the distance between the grids. The theoretical shape of the current curve is compared with experiment and good agreement observed. Measurements have been made between X/p of 0.03 and 20, and the values obtained are compared with the Compton mobility equation. The existence of inelastic impacts for electrons of low energy (1–3 volts) seems highly probable.

FRIDAY AFTERNOON AT 2:00 P.M.

11. Progress on a Deflection Determination of (e/m). FRANK G. DUNNINGTON,* *California Institute of Technology.*—Work instigated at the University of California[1] and continued in Pasadena has progressed to the point where final observations are being started. Characteristic probably of most experimental investigations when pursued far enough, the initially observed simple phenomenon has been found to be affected by various secondary phenomena. The first phase of the observational work has been concerned with a study of these and the conditions necessary for their elimination. In the second phase the taking of final observations will be made with a series of varying conditions in such a way as to experimentally determine, if possible, the necessary correction to the angular path of the electrons. A more exact mathematical analysis than that presented in the earlier work is also being made but the assumptions necessary to give a solvable problem make an experimental determination desirable.

* Carried out under grant from the American Philosophical Society.
[1] F. G. Dunnington, Phys. Rev. **43**, 404 (1933).

12. Mass-Ratio of the Lithium Isotopes. F. A. JENKINS, *University of California,* AND ANDREW MCKELLAR, *Dominion Astrophysical Observatory.*—Almy and Irwin[1] have determined the mass-ratio given by the isotope effect in the red band system of Li_2. Their conclusions are tested by new measurements of this system on plates taken with the 35-ft., 30,000 line/in.-grating at the Massachusetts Institute of Technology. The bands 5,0 to 0,0 of the $v',0$ progression and 0,0 to 0,4 of the $0,v''$ progression, as well as 1,1, were measured for both the main and isotopic systems. The vibrational and rotational constants were evaluated by methods previously used by one of us for the blue-green system. The most accurate values found for the isotopic mass-coefficient ρ are $\omega_e'^{\Delta}/\omega_e' = 1.04100$ and $\omega_e''^{\Delta}/\omega_e'' = 1.04107$, compared with the values 1.04141 previously obtained from the blue-green system. Almy and Irwin obtained 1.04077, agreeing exactly with the mass-spectrum value. Our new values have a much greater accuracy than those from the blue-green system, because of the higher dispersion and the elimination of blends, which introduced systematic errors in the earlier results. The difference between the new values and those of Almy and Irwin is ascribed to the method of handling the data, our method having the advantage of directness and emphasis on the states of lower vibrational quantum number, where complications are less likely to be important. Full details will be published, probably in the Publications of the Dominion Astrophysical Observatory.

[1] Almy and Irwin, Phys. Rev. **48**, 104 (1935).

13. Neutrons from the Disintegration of Deuterium by Deuterons. W. M. BRUBAKER AND T. W. BONNER,* *California Institute of Technology.*—The excitation functions for the emission of neutrons from the two reactions $_1H^2 + {}_1H^2 \rightarrow {}_2He^3 + {}_0n^1$ and $_4Be^9 + {}_1H^2 \rightarrow {}_5B^{10} + {}_0n^1$ have been investigated in the energy range of from 0.5 to 0.9 MEV. In this interval the yield of neutrons from a $H_3^2\,PO_4$ target increases linearly with the bombarding energy while the yield from a Be target increases nearly exponentially. At 0.9 MEV three times as many neutrons were observed from the Be target as from the $H_3^2\,PO_4$ target. At 0.5 MEV only 1/3 as many neutrons came from the Be as from the $H_3^2\,PO_4$. The neutrons from deuterium were found to be nearly homogeneous in energy with a maximum of 2.55 MEV when they are observed at right angles to the direction of the incident 0.5-MEV deuterons. The energy of the disintegration is 3.21 ± 0.13 MEV.

* National Research Fellow.

14. Passage of X-Rays Through Oscillating Crystals. R. M. LANGER, *California Institute of Technology.*—The distortions suffered by crystals subjected to piezoelectric oscillations not only broaden the band of wave-lengths the crystal can reflect into a particular spot of a Laue pattern but they widen the cone of reflected light as well. This is the now generally accepted explanation of the enhancement of Laue patterns by piezoelectric oscillations first observed by Fox and Carr.[1] To observe the widening of the spots it is necessary to use a well collimated beam of x-rays. An extension of the original theory[2] shows the necessity of taking into account the reflections from the reflected beams back into the initial direction. Because of the inhomogeneous distortions of the piezoelectric crystal the multiply-reflected portion of the beam will be even more widened than the singly reflected portions. This means that the central spot will be enlarged by contributions from all the other spots. These contributions will amount to a very small fraction of the direct beam intensity but since they appear outside the completely fogged normal spot they make it appear appreciably enhanced. This may be the interpretation of the curious observation reported by Fox and Fraser.[3] The results of Jauncey and Deming[4] are not inconsistent with Fox and Fraser's experiments when the present theory is taken into account.

[1] Fox and Carr, Phys. Rev. **37**, 1622 (1931).
[2] R. M. Langer, Phys. Rev. **38**, 573 (1931).
[3] Fox and Fraser, Phys. Rev. **47**, 899 (1935).
[4] Jauncey and Deming, Phys. Rev. **48**, 462 (1935).

15. Positrons from Deuteron Activated Phosphorus. H. G. PAXTON (*Introduced by* E. O. LAWRENCE), *University of California.*—Phosphorus activated through deuteron bombardment was investigated in a cloud chamber traversed by a magnetic field. Absorbing screens were placed in the chamber in such a fashion that a definite region was primarily available to positrons. Just after the short contamination periods had died out, about one positron was observed for every fifty electrons from P^{32}. The relative numbers of positrons per expansion on series of photographs scattered over more than a week indicate a half-life of 50 ± 10 hours. Consequently these positrons are neither associated with the electron decay of P^{32}, nor do they arise from any known contaminant. The energy distribution appears to have the form of a disintegration spectrum with its upper limit at about 0.9 MV. Chemical tests to identify this positive activity are in progress.

16. The Calculation of Binding Energies in Light Nuclei. WILLIAM V. HOUSTON, *California Institute of Technology.*—If the forces between the nuclear constituents are proportional to the distance between them, the energy levels can be easily calculated by using normal coordinates. If the functions for the ground state in this model are taken as approximate functions with one variable parameter, the energy of the ground state can be computed on the assumption that the force between protons and neutrons is harmonic out to a given distance and then becomes zero. The correction to the function necessary to minimize the energy is relatively small, which lends support to the belief that the approximation functions are rather good. From the masses of H^2, H^3, and He^4 rather narrow limits can be set to the parameters of the force.

17. Radioactivities of Zinc under Deuteron Bombardment. J. J. LIVINGOOD, *University of California.*—When zinc is bombarded with 4-MEV deuterons, a radioactivity is induced exhibiting several periods. The decay curve can be analyzed into components with half-lives of approximately 100 hours, 15 hours and 1 hour, with the possibility of a shorter period of some minutes. Chemical analysis indicates that the active bodies are zinc isotopes, suggesting that the disintegration is of the Oppenheimer-Phillips type, wherein the neutron of the deuteron is captured. The excitation functions rise rapidly after a threshold near 1.5 MEV, and are sufficiently different from that of sodium bombarded by deuterons to assure that the 15-hour activity is not due to sodium contamination.

18. Spray Electrification. SEVILLE CHAPMAN (*Introduced by* L. B. LOEB), *University of California.*—Preliminary to a study of nonaqueous polar liquids, the mobility spectrum of spray electrified salt solutions has been investigated with an Erickson mobility tube under conditions of high resolving power. In general, the curves of electrometer deflection against mobility show no charged carriers with mobility above 1.6 cm/sec. per volt/cm. About this mobility the curve rises sharply to a roughly constant value with a general broad maximum band in the region 0.05 cm/sec. per volt/cm, and then gradually decreases to zero. Superposed on this "background" *striking* peaks were observed. Negative and positive groups for solutions indicated are shown below. The first number represents approximate mobility in cm/sec. per volt/cm. The letter indicates roughly the strength of the peak with respect to the "background." VS, very strong; S, strong; M, medium; W, weak. The next number indicates relative electrometer deflection.

	Negative			Positive		
Solution	*A*	*B*	*C*	*A'*	*B'*	*C'*
4×10^{-2}N KCl	1.2 W 0.6	0.7 M 1.7		1.1 W 0.5	0.6 M 1.9	
4×10^{-3}N KCl	1.2 W 4	0.5 S 8		1.1 W 3	0.4 M 7	
4×10^{-4}N KCl	1.2 M 9	0.4 S 13		1.0 W 8	0.4 VS 15	
4×10^{-5}N KCl	1.2 S 14	0.36 M 15			0.4 VS 18	
4×10^{-6}N LiCl	1.2 S 11	0.4 M 13		1.0 W 7	0.4 VS 17	
4×10^{-6}N NaI	1.2 S 10	0.36 M 14		1.0 M 7	0.4 VS 20	
4×10^{-6}N KCl	1.2 VS 12	0.3 W 8	0.2 W 10		0.4 S 9	0.2 W 9
Distilled Water	1.2 VS 11	0.3 W 6	0.2 M 9		0.5 M 6	0.22 W 7

19. Electric Influence of the Active Region of the Sun. FERNANDO SANFORD, *Stanford University.*—In the August, 1935, number of *Publications of the Astronomical Society of the Pacific* it was shown that there is a local region of high solar activity and a corresponding region of low solar activity on opposite sides of the sun. These regions are shown to have crossed the sun's central meridian at successive intervals of 27.25 days during two periods of 80 solar rotations each, including two periods of maximum sun-spot activity. It is the purpose of this paper to inquire if the electrical influence of solar activity upon the earth varies with the rotation period of the sun. Five different sets of observations of terrestrial electric phenomena have been compared with the variation of solar activity as

shown by relative sun-spot numbers. These consist of daily range of variation of earth potential at Palo Alto, daily range of N–S earth-current variation, daily maximum of N–S earth-currents, character figures of atmospheric potential curves and missing days in earth-current records, all at Ebro Observatory. In all five cases there are indications of a 27.25-day period in phase with the variation of solar activity.

20. Kinematics and World Structure, II. H. P. ROBERTSON, *Princeton University.*—It has been shown previously that any cosmological theory in which the nebulae are considered as particles in homogeneous flow leads automatically to a space-time line-element whose formal properties are identical with those of the metric on which the general relativistic theory is based. This investigation is here continued with an examination of the equations of motion of test particles in such a universe; these are shown to involve a single unknown function, and the problem of their integration is reduced to the solution of a single ordinary differential equation. The acceleration function implied by various gravitational theories is determined, and the properties of the motion discussed.

21. Artificial Radioactivity Induced in Arsenic, Nickel and Cobalt under Deuteron Bombardment. R. L. THORNTON, *University of California.—Arsenic.* A layer of arsenic, sublimed on aluminum, was bombarded with 4.3-MEV deuterons. Observations showed the presence of two additional active substances. Of these, the shorter period effect (2.5 hours) can be ascribed to silicon impurity in the aluminum base. The longer period of 27 ± 1 hours has been shown by Fermi and his collaborators to be due to As^{76}. Strong γ-rays accompany this activity. Rough absorption measurements in lead and copper show these to be considerably less energetic than those of radio-sodium. Absorption measurements have been carried out on the disintegration electrons. These indicate a maximum energy of about 1.5 MEV. *Nickel.* A stack of nickel foils 0.001 inch in thickness was bombarded with 5.2-MEV deuterons. Periods of 10 minutes and $3.5+.1$ hours were observed. Plotting the activities against the deuteron range a differential excitation curve was obtained for the longer period. This gives a linear relation between yield and range for deuteron energies greater than 3 MEV. The short period activity observed is probably due to carbon contamination. The chemical tests have not yet been carried out. *Cobalt.* Activities of at least three periods were observed from a cobalt target bombarded with 4.3-MEV deuterons. These were 10 minutes, 3.6 hours and one or more weak activities of period longer than a day. The 10-minute activity can almost certainly be ascribed to carbon contamination. The 3.6-hour effect may be due to the same active isotope as the one of like period observed in nickel. The relative intensities of the effects observed make Ni impurity as a cause improbable.

SATURDAY MORNING AT 9:00 A.M.

22. The Transmutation of Argon by Deuterons. ARTHUR H. SNELL, *University of California.*—When bombarded with high speed deuterons, argon gas is found to yield a radioactive product which emits negative electrons, and decays with a period of 108 ± 4 minutes. Chemical tests show that the activity is due to an isotope of argon, and the reaction is probably $A^{40}+H^2=A^{41}+H^1$. Absorption measurements of the β-particles indicate that their maximum energy is about 1.1 MV. This is in satisfactory agreement with the results of a cloud-chamber study of their energy-distribution curve, which shows an upper limit at about 1.8 MV, although there is some indication of a second group of low intensity and higher energy. The radioactivity is accompanied by the emission of a γ-ray, the energy of which is 1.5 MEV, as measured by the energies of its Compton recoils in a cloud chamber. The excitation curve for the radioactivity has also been studied. It favors the Oppenheimer-Phillips theory for this type of reaction, rather than the Gamow theory of the penetration of the potential barrier by a charged particle. Formation of A^{41} starts when the deuteron energy reaches 2 MEV.

23. Optical Changes in Freshly Evaporated Al-Mg Films. HIRAM W. EDWARDS AND ROBERT P. PETERSEN, *University of California at Los Angeles.*—This paper deals with a study of reflection and transmission characteristics of freshly evaporated films of an Al-Mg alloy. Apparatus was arranged inside of an evaporation chamber so measurements could be made during and after deposition of the metallic film. Three types of changes in reflection and transmission coefficients were observed: (1) (Occurring at pressures of 10^{-4} mm or less). This consists of a small, rapid decrease in reflectivity and increase in transmissivity. One minute is required for this change. The transmission coefficient alters more rapidly than the reflection coefficient. No further effect takes place in the vacuum. (2) The second type occurs during admission of air or nitrogen into the vacuum chamber. It consists of decrease in reflectivity and increase in transmissivity. The rate of change is definitely dependent upon the rate of increase of pressure in the vacuum chamber. (3) This type takes place very slowly, over a period of several days. The final value of the reflection or transmission coefficient is approached asymptotically. The magnitudes of the three types of changes for a film having an initial reflection coefficient of 58 percent were observed to be 8 percent, 5 percent, and 10 percent, respectively; and for another film having an initial transmission coefficient of 35 percent were 5 percent, 8 percent, and 5 percent.

24. On the Figuring and Correcting of Mirrors by Controlled Deposition of Aluminum. JOHN STRONG AND E. GAVIOLA, *California Institute of Technology.*—By controlled deposition of metals, evaporated in vacuum, it is possible

to change the figure of reflecting surfaces quantitatively. The theory for calculating screens and the experimental technique are described. A spherical 12-inch mirror has been repeatedly parabolized, obtaining a surface perfect within 1/20 of a wave-length. A 5¾-inch spherical mirror has been parabolized with the optical axis outside of its periphery. A defective parabolic mirror was corrected of turned up and down edges and asymmetric zones. A convex spherical Cassegrain mirror was hyperbolized. The possible applications and the limitations of the method are discussed.

25. Electric Force *versus* Centrifugal Force. CHARLES T. DOZIER, *Redding, California.*—Revolution of a tungar-type vacuum tube about an external axis, with plate-to-filament gap radial, alters the plate current at constant plate potential and filament temperature in direction opposed to that hitherto expected from the action of centrifugal force on "positive-mass" electrons in the gap. By postulating the electric current in the gap to consist of a one-to-one exchange of electrons and more massive positive particles, the plate current changes agree, in direction, with observation. Quantitatively there is wide variance. With plate radially outward and sufficient excess voltage to maintain constant plate current against the resultant of centrifugal force on electrons and postulated positive particles in the gap, the ratio of these forces in dynes at varying speeds approximates the number 2.2×10^{8}. The electric force, in dynes, is the larger. It is noticed that the ratio of this number, (2.19×10^{8}), to the velocity of light is 137 cm/sec., the fine-structure constant of wave mechanics. The dimensions of the fine-structure constant $hc/2\pi e^2$ are those of $1/\kappa$ and $(L^2/T^2)\mu$. These dimensions agree with the above result when both κ and μ have dimensions of the velocity invert T/L. Then, in dimensions, $1/\kappa\mu = L^2/T^2$.

26. The Spectra of Sa II and Gd I. WALTER ALBERTSON, *National Research Fellow, Mount Wilson Observatory.*—With the use of King's data the major portion of the spectrum of Sa II has been classified (1200 lines). The normal state is $4f^6(^7F)\cdot 6s\,^8F$, 1500 cm^{-1} above it is found ^6F from the same configuration. The multiplet intervals are almost identical with those of ^7F of Sa I. Approximately 10,000 cm^{-1} above ^8F is the pentad $4f^6(^7F)\cdot 5d\,^8HGFDP$, which, except for ^8G, ^8F, has been completely found. No violent overlapping or perturbations occur among the multiplets. The triads $4f^6(^7F)\cdot 6p\,^8GFD^0$, $^6GFD^0$ have been tentatively picked out. About 200 other middle odd levels are believed to be due to $4f^5 5d6s$. The transition $6p-6s$, built on parent ^7F, accounts for nearly every intense line from 5000A to 4200A, and $6p-5d$ nearly every line from 9000A to 5500A. The lines from 4200A to 2900A belong mostly to $4f^5 5d6s - 4f^6(^7F)\cdot 6s$. The transition $4f^5 5d6s - 4f^6(^7F)\cdot 5d$ is represented by only a few lines, all weak. Zeeman effect measurements and additional data for fainter lines are being obtained by King and the writer. The $^7D^0$ multiplet from $4f^7(^8S^0)\cdot 5d6s^2$ of Gd I has been found at about 6000 cm^{-1} above the normal state, $^9D^0$, from the same configuration. Numerous intense combinations in the orange and red have been classified as combinations to the ground levels, the upper levels being tentatively assigned to $4f^7(^8S^0)6s5d6p\,^{11}FDP$.

27. Transmutation Functions at High Bombarding Energies. HENRY W. NEWSON, *University of California.*—The transmutation functions of the reactions:

$$C^{12}+D^2=N^{13}+N^1, \quad N^{14}+D^2=O^{15}+N^1,$$
$$O^{16}+D^2=F^{17}+N^1$$

have been measured for bombarding energies up to 5 MV. The deuteron beam was passed through a stack of 10 platinum foils, spaced about 3 mm apart in an atmosphere of the gas under investigation. The number of recoil atoms deposited was determined by measuring the activities of the foils with an electroscope. By knowing the stopping power of the gas and of the foils the excitation curve may be plotted. The excitation curves of the three elements showed the rapid initial rise which is to be expected, and then became nearly flat. The bombarding energy at the beginning of the flat portion of the curve is presumably the energy corresponding to the top of the potential barrier. The values for the top of the potential barriers so estimated are 3.3, 3.7 and 3.8 MV for carbon, oxygen and nitrogen, respectively. These values are probably high since no correction was made for the variation of the mean forward range of the radioactive recoil atoms with the bombarding energy. Although the form of this correction is not known, its effect will be to cause the excitation curve to flatten at lower energies and to fall off thereafter as the bombarding energy is increased.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.

28. The Radiations Emitted by Radio-Aluminum. J. M. CORK, J. R. RICHARDSON AND F. N. D. KURIE, *University of California.*—Radio-aluminum (Al^{28}) is formed from ordinary aluminum when the latter is bombarded by high speed deuterons. This substance can be made in several other ways, and is known to emit both β- and γ-rays. The half-life measured by either of these radiations is the same (2.6 min.). The γ-rays have been studied in a Wilson cloud chamber by measuring the curvatures produced by a known magnetic field on the secondary electrons ejected from a thin glass lamina suspended in the chamber. The electrons are distributed over a range of energies corresponding to what would be expected under these conditions for a monochromatic γ-ray. The energy of this γ-ray is 2.3 MV. The β-ray spectrum is a typical continuous distribution. If the data are considered alone an upper limit of 3.3 MV is indicated, but if the data have a Konopinski-Uhlenbeck curve fitted to them an upper limit of 3.7 MV is found.

29. On a Mechanical Method for Computing the Energy Values to be Associated with a Fork in a Cloud Chamber Caused by the Disintegration of a Nucleus by a Neutron. F. N. D. KURIE AND J. J. LIVINGOOD, *University of California.*—The tedium of computing and rechecking the energies associated with the two visible disintegration particles and the neutron, when a reaction of the type $N^{14}+n^1=B^{11}+He^4$ is observed in a cloud chamber, can be greatly relieved by mechanical means. Such a mechanical device has been constructed. It consists of two arms pivoted at one end bearing scales on which both energy and range are marked at distances from the pivot which are proportional to the momentum of the appropriate particle. Sliders on these arms carry a third arm and pointers. The two sliders are set at the observed ranges of the two disintegration particles and the arms swung on their pivots to the angle between the tines of the fork. The energy of the impinging neutron is read on the third arm and that of each of the observed particles on the other arms. Since the angle between the tines of the fork is not measured directly from the cloud chamber photographs it is computed separately on a sphere from the observed altitude and azimuth of each tine. With this device the complete analysis of a disintegration fork is accomplished in about two minutes as against the twenty to thirty required for the longhand computations.

30. The Measurement of Gamma-Ray Energies with a Cloud Chamber. J. R. RICHARDSON AND F. N. D. KURIE, *University of California.*—The only reliable method of measuring γ-ray energies is by the use of a cloud chamber traversed by a magnetic field. The curvature of the tracks of secondary electrons from the radiator is measured. From a frequency distribution of the tracks in radius (strictly in $H\rho$) one estimates the energy of the γ-ray. This work tests the resolution and defines criteria for a homogeneous γ-ray. For radiators composed of light elements, one may neglect photoelectrons and pair production and consider only Compton electrons. The relative numbers of electrons ejected at various angles may be computed from the Klein-Nishina formula. For any given angular range (here taken as within 10°) of the direction of the γ-ray, one may calculate the distribution in energy of the electrons emerging from various depths in the radiator from the known data on the straggling of β-particles. Thus curves can be constructed which show the energy distribution of these secondary electrons for various thicknesses of radiator. One finds from such an analysis that the best conditions are attained by the use of a thin lamina of the order of 100 mg/cm² thick and using only such tracks as emerge within an angle of about 10° with the γ-ray. In this way peaks whose half-width is about 300 kv can be got for each homogeneous γ-ray (provided the energy is of the order of 3 MV).